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(PERFORMANCE OF AGRICULTURE IN THE SEMI-ARID REGION
OF UTTAR PRADESH: AN INTER-DISTRICT ANALYSIS*)

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This paper examines agricultural development issues in the semi-arid
region of Uttar Pradesh, India's largest state.   It makes a comparative
study of the process of agricultural development in five districts under
the DPAP (which come under ICRISAT's definition of SAT) and in five
adjoining districts. The study encompasses two time phases representing
the periods before and after the "green revolution." The authors examine
differences in crop output growth, inter-district differentials in growth
in terms of output as well as components, and identify major factors
associated with such differentials. They conclude that while massive
public investment in irrigation would offer a sure long-term solution to
problems of agricultural development in the SAT of U.P., it may also be
essential to develop a new dry-crop technology which provides higher
yields.

In Uttar Pradesh (UP), as many as 20 districts have been identified as semi-arid by a task force of the Government of India[1]. As they account for about 42 percent of UP's gross cropped area (1975-76), the performance of these districts significantly contributes to the stability or otherwise of agricultural production in the State. Five of these 20 districts -- Jhansi, Jalaun, Hamirpur and Banda from Bundelkhand, and Mirzapur -- have been adopted by the State Government for the Drought Prone Area Programme (DPAP). These semi-arid areas have only recently begun to engage the attention of policy makers and social scientists, probably because the new agricultural strategy has hardly offered any benefits to them.

In fact, the new technology has helped mainly regions with favorable factor endowments and higher growth potential, thus accentuating the disparities in agricultural development among different regions and districts of the State.[2]   However, the disparities in agricultural development become more pronounced for the semi-arid region, as the risk involved in agriculture is quite high due to low rainfall and irrigated area. This, coupled with the farmers' tendency toward risk aversion, leads to underinvestment in agriculture.[3]   That there had been substantial decline in productive assets during drought years and slow recovery of such assets in postdrought periods,[4] supports the hypothesis that there is a strong risk-induced tendency toward permanent underinvestment in drought-prone areas[5].   For this hypothesis to be valid, however, we need to study the pattern of investment on different components. For instance, investment in irrigation may be low in the semi-arid areas due

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1 See "Interim Report of the Task Force on Development of Semi-arid/ Rainfall Areas", Ministry of Agriculture and Irrigation, Government of India, New Delhi, July 1978 (Mimeo).

2 Tyagi, B.M. "Study of the Impact of Green Revolution on the Regional Development of Agriculture in UP" Indian Journal of Agricultural Economics, Vol. XXIX, No.4, October-December 1974.

3 Binswanger, H.P. "Risk Attidues of Rural Households in Semi-Arid Tropical India", Economic and Political Weekly, Vol. XIII, No. 25, June 24, 1978.

4 Jodha, N.S. "Effectiveness of Farmers Adjustments to Risk", Economic and Political Weekly, Vol. XIII, No. 25, June 24, 1978.

5. Ibid.

to lack of availability of groundwater. On the other hand, the invest-
ment in tractors may not be low, because the sowing period is quite short
owing to the unlimited number of rainy days and the success of the crop
becomes largely the function of the farmers' capacity to complete the
sowing operations in the available time, which may induce them to
acquire tractors.[6]

An attempt has been made in this paper to verify the above proposi-
tions in the case of the semi-arid region of Uttar Pradesh by making a
comparative study of the performance of agricultural development (as
shown by crop output growth and its components) in the five districts
under the DPAP[7] and in five adjoining districts, in two phases covering
the periods: 1962-65 to 1968-71 and 1968-71 to 1974-77. These periods
were chosen to represent the pre- and post-green revolution periods
respectively. The specific issues examined in this paper: (i) what is the
magnitude of the difference in crop output growth in these areas between
the pre- and post-HYV periods? (ii) how do inter-district differentials
in growth, not only in output but also in its components, i.e. area,
yield and cropping pattern, compare between pre- and post-HYV periods? and
(iii) what are the major factors associated with inter-district differentials
in the growth of crop output?

SEMI-ARID DISTRICTS IN UP

The following are the 20 districts identified by task force as semi-arid
rainfall farming areas; Agra, Bijnor, Badaun, Moradabad, Shahjahanpur,
Kanpur, Fatehpur, Allahabad, Jhansi, Jalaun, Hamirpur, Banda, Ghazipur,
Unnao, Sitapur, Hardoi, Kheri, Hampur, Mirzapur and Bareilly. When these
districts were included in the semi-arid category, the extent of irrigated
area in each of them was less than 33 percent. But since then sizable
increases have taken place in the irrigated area in most of these districts.
For instance, only 22 to 23 percent of cultivated area was reported under
irrigation for Bijnor and Badaun districts according to the Task Force.
By 1975-77, the irrigated area in these districts had increased to 38 to
40 percent.

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6 Jodha, N.S. "A case of the process of tractorization", Economic and
   Political Weekly, Vol.IX, No.52, December 28, 1974.

7 These five districts, are the only ones which are included in ICRISAT's
   definition of the semi-arid tropics of UP.

But in the five DPAP districts included in this study - Jhansi, Jalaun, Hamirpur, Banda and Mirzapur - rainfall is low, ranging from 851 to 946 mm, and the irrigated area is also still quite low, ranging from 15 to 24 percent. These districts form a contiguous area and are among the most backward.

For comparison, we have also analyzed the performance of agriculture in the adjoining districts of Etawah, Kanpur, Fatehpur, Allahabad and Varanasi. In terms of rainfall, these districts are more or less at par with the drought-prone districts (between 752 to 1052 mm.), but have higher irrigated areas ranging between 34 and 55 percent. They do not come within the definition of semi-arid tropical areas used by ICRISAT. A comparison between these two groups of districts may bring out some of the factors associated with inter-district differentials of crop output growth.

CROP OUTPUT GROWTH: COMPONENT ANALYSIS

The growth of crop output and its components: area, yield, cropping pattern as well as their mutual interactions, have been analyzed with the help of an additive decomposition scheme (the details of the decomposition methodology are given in Appendix I). The compound annual rates of growth in crop output during 1962-65/1968-71 were higher, ranging from 0.71 to 2.73 percent, than they were during 1968-71/ 1974-77, when growth rates turned out to be negative, ranging between -0.56 to -2.25 percent in Jhansi, Hamirpur and Banda districts, and positive in Jalaun and Mirzapur districts at 1.14 and 0.87 percent respectively. Except in Jalaun, where the growth of crop output was higher in the later period than the earlier period the crop output showed a declining trend in all the semi-arid districts. In the adjoining districts also, except in Allahabad the growth in crop output in the later period was lower than in the earlier period (Table 1).

Thus, the period since 1968-71 has witnessed a distinct deceleration in growth of crop output in both sets of districts. But while the adjoining districts have maintained an upward trend in output growth, the semi-arid districts have in general experienced a declining trend during this period. It is interesting to note that the growth rates in the semi-arid districts by and large were higher than those of adjoining districts in the earlier period. In Jhansi, Hamirpur and Banda crop output increased at the rates of 2.1 to 3.9 percent per annum, whereas in all the adjoining districts the growth rates were less than 1.8 percent except at Kanpur, which has shown a higher crop output growth

at 3.28 percent. The higher percentage growth in the semi-arid districts
in the earlier period is, to a certain extent, a reflection of lower base
levels; yet it is intriguing that a general decline set in during the
subsequent years. An analysis of the sources of output growth presented
in the following paragraphs may throw some light on this aspect.

Over the entire period of study, yield rather than area has been the
major source of crop output changes in both semi-arid and adjoining
districts. Whatever contribution the area made was primarily during the
period 1962-1971. The contribution of area was 9 to 23 percent positive
in the semi-arid districts of Jhansi, Hamirpur and Banda and almost 100
percent in Jalaun, and negative to the extent of 42 percent in Mirzapur,
during this period. In adjoining districts, the contribution of area
increase was positive in all the districts ranging from 20 to 30 percent
in Etawah, Fatehpur, and Varanasi, whereas in Kanpur and Allahabad its
contribution was negligible (2 to 5%). In the later period, contribution
of area declined in all the districts (Table 2A and 2B).

Yield increase, on the other hand, contributed a major part of the
output growth in both the earlier and later periods, and in both semi-arid
and adjoining districts. In adjoining districts, the yield increase
accounted for about 59 to 86 percent of crop output growth in Etawah,
Kanpur, and Varanasi. In the group of semi-arid districts, its contribut-
ion to output growth was 78, 80, 56 and 148 percent in Hamirpur, Banda,
Jhansi, and Mirzapur, respectively, but 27 percent negative in Jalaun in
the earlier period, and 37 to 42 percent in Fatehpur and Allahabad. In
the period 1968-71 to 1974-77 the decline in yield contributed signi-
ficantly to decrease in output: except in Jalaun where yield increase
contributed to output growth. In the adjoining districts, the contribu-
tion of yield increase to output growth was quite high, ranging from 61
to 110 percent. Thus, whether it was decline in the semi-arid districts
or increase in the other districts, the output change in all these
districts came from yield during the later period of the study.

The adjoining districts, with more or less similar rainfall and soil
characteristics (indicated by soil rating in Table 3) as that of the
semi-arid districts, could maintain an increase in yield over the entire
period as they were in a better position in terms of other resources such
as irrigation facilities and fertilizer use, which are the important
ingredients of the new technology. As the semi-arid districts lack
irrigation facilities, not only could the yield increases from the earlier
period not be sustained, but a declining trend set in during the subsequent
years, causing a fall in output.

As regards the crop-pattern component of output growth, its positive direction is indicated by shifts from low-value to high-value crops. In the earlier period, the contribution of crop pattern was positive in Jhansi, Jalaun, and Mirzapur districts, ranging from 20 to 33 percent of output growth. In Hamirpur and Banda, its contribution was almost negligible whereas among the adjoining districts of Fatehpur and Allahabad, the crop pattern contributed to output growth by about 55 to 57 percent, and in Etawah and Kanpur its contribution was only marginal, 2 to 5 percent. In Varanasi, the crop pattern shifted from high- to low-value crops, with the result its contribution turned out to be negative though to the limited extent of 5 percent.

In the later period (1968-71 to 1974-77), the contribution of crop pattern to output growth was more or less of the same magnitude as in the earlier period in all the semi-arid districts, except for Mirzapur in which this contribution increased from 10 percent to 30 percent. In the adjoining districts, the contribution of crop pattern to output growth increased from 2 to 5 percent in the earlier period to 13 to 25 percent in the later period of Kanpur and Etawah. In Varanasi, the contribution was negative in the earlier period but became positive in the later period (61%). The reverse was the case with Fatehpur and Allahabad, where the contribution of crop pattern to output growth decreased from 55 to 57 percent in the earlier period to 4 to 19 percent in the later period respectively.

The contribution of crop pattern to output growth for both periods in the semi-arid districts clearly suggests that wherever the shifts from low-to high-value crops have taken place in the initial period, they have been maintained in the later period also. Thus, the contribution of crop pattern to output growth was maintained at the same level in both the periods in most of the semi-arid districts. These districts which could not maintain the yield level obtained in the earlier period through the subsequent years, were able not only to maintain the initial shifts that took place in crop pattern from low- to high-value crops but also to improve further in this regard, at least in some cases (for crop-pattern shifts see Appendix II). For example, in Mirzapur the crop pattern had a higher contribution to output growth in the later period than it did in the earlier period. This suggests that the farmers of the semi-arid region are also alive to the objective of maximizing returns from crops within their resource constraints.[8]   However, due to the low extent of

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[8] Similar observation has been made by Baldev Singh. In his study, it has been found that even the creation of irrigation facilities has not made much impact on the intensity of land use and labor input in an arid region. However, farmers have tried to increase their incomes in such areas through crop pattern shifts from low value to high value crops. See, "Economies of Irrigation: A Regional Perspective (A Case Study in DPAP District Surendra Nagar)" Indian Journal of Agricultural Economics, Vol. XXXIII, No.4, October - December 1978.

irrigated area, the scope for large-scale shifts from low- to high-value crops is limited in the semi-arid districts.

FACTORS ASSOCIATED WITH YIELD-GROWTH DIFFERENTIALS

Having observed that yield changes have been mainly responsible for the changes in output, let us now look at the contribution of various factors in determining the variations in yield-growth.

The factors included in analysis here are: land-holding size, distribution and ownership, fertilizer use, irrigation, pump sets, mechanical power, and density of rural population. An attempt has been made to examine the behavior of these factors over time in relation to yield-growth and also to explain the interdistrict differentials in growth of crop output and per acre yield mainly for the period 1968-71 to 1974-77. The main reason for excluding the earlier period is the superficially high rates of yield-growth shown by semi-arid districts in that period due to low initial levels, which pose methodological problems in comparison. In view of the non-availability of data for all factors on a time series basis, the analysis attempting to explain the differentials in yield-growth has been made on a cross section basis.

Landholdings: Size, Distribution and Ownership

Average sizes of holdings were found in the vicinity of 2.50 hectares in the semi-arid districts as against 1.10 hectares in adjoining districts; land concentration ratio did not significantly differ between the two groups of districts; owner cultivation was found generally lower in the semi-arid districts than in others. As pointed out earlier, yield-growth was significantly higher in the adjoining districts than in the semi-arid districts. The association of higher average landholdings with lower yield-growth here does not necessarily reflect a size and yield-growth relationship, as the differences in this instance are mainly due to the inferior soil of semi-arid districts as indicated by lower soil-rating scores[9] (Table 3), with higher average

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9 The soil-rating scores include degree of weathering, texture structure, stoniness, salinity, permeability, profile, natural fertility, see Shome, K.D., and Ray Choudhuri S.P., "Soil Ratings; Proceedings National Institute of Sciences of India, 1960."

size of landholdings. For the same reason, it does not contradict the
general expectation that the large-sized farms show a better yield-
growth due to their capacity to use more new inputs initially as well
as subsequently.

Fertilizer Use

The impact of fertilizer use on yield-growth can be studied only by a
crop analysis, as it is generally applied in a few important crops only.
Due to this limitation, the precise relationship between fertilizer use
and yield-growth is difficult to establish. Nevertheless, to have a
general idea about the impact of fertilizer use on the yield-growth, the
per hectare fertilizer use for P_2O_5 and N_2 separately for the years
1962-63, 1969-70 and 1975-76 and yield-growth for both periods:1962-65 to

1968-71 and 1968-71 to 1974-77 were analyzed (Table 4). The yield-growth
in the earlier period was positive in all the districts in both categories,
except in Jalaun where the yield-growth was negative to the extent of 0.2
percent per annum. In the later period, the yield-growth was positive in
all adjoining districts, whereas in semi-arid districts the yield-growth
was negative, the extent ranging between 0.42 to 2.04 percent per annum,
except in Jalaun where the yield increased 1.32 percent per annum. If we
see the behavior of fertilizer use over a period, it is evident that
there had been a tremendous increase in fertilizer use in 1969-70 over
1962-63 for both P_2O_5 and N_2, though the quantum of fertilizer use was
lower in the semi-arid districts than in the adjoining districts. This
appears to be the reason for the declining yield in the later period in
semi-arid districts. The year 1974-75, which was bad in terms of rain-
fall, also affected very badly the yield rates in the semi-arid districts.
In adjoining districts, the effect of this year was less due to the
higher irrigated area in these districts. However, despite the low
quantum of fertilizer use, there was an increase in yield level in the
earlier period, probably because traditional varieties of seeds were
used to give response even at low levels of fertilizer use. The other
reason seems to be the low level of yield initially.

    Fertilizer use in adjoining districts has been much higher for both
P_2O_5 and N_2. Since the yield-growth was by and large higher in adjoining
districts than in the semi-arid districts, it could be said that the
districts with a higher use of fertilizers tend to show high yield growth
also. But the relationship does not seem to hold in a precise manner.
It seems that a given increase in fertilizer input does not show
corresponding quantitative effects on yield growth, probably due to
variations in irrigation facilities.

Irrigated Area

Though there has been an increase in the ratio of irrigated to total
cropped area in both semi-arid and adjoining districts, the extent of
irrigation is still quite low in semi-arid districts, less than 30
percent. Therefore, whatever the increase in irrigated area that had
taken place in 1974-77 over 1968-71, it could not arrest fluctuations
in yield rates; in some places there was a decline in yield, despite an
increase in the irrigated area. For instance in Banda, the increase in
irrigated area in 1975-76 over 1969-70 was about 34 percent, but yield
declined at the rate of 2.04 percent per annum in the later period,
whereas the irrigated area in 1969-70 over 1962-63 decreased by 12
percent, but yield-growth was positive in this period (Table 5).
Similar is the case in Mirzapur. These trends clearly suggest that a
small increase in the irrigated area in semi-arid districts is probably
not of much help to yield-growth. It appears that there is a critical
minimum level for irrigated area, and only increases above this level
would begin to show increases in yield-growth.

     Coming to the adjoining districts, it appears that the increase
in irrigated area has to a certain extent helped the yield-growth
unlike in the semi-arid districts. For instance, in Etawah and Kanpur,
the increase in irrigated areas in 1969-70 over 1962-63 was higher than
in 1975-76 over 1969-70; the yield-growth was also higher in the earlier
period than in the later period in both districts. In Fatehpur and
Allahabad, the increase in irrigated area in 1975-76 over 1969-70 was
two to three times higher than in 1969-70 over 1962-63 and the yield
also turned out to be higher. This suggests that the increase in
irrigated area has been influencing the yield-growth mainly in those
districts where the extent of irrigated area happens to be high,
ranging between 35 to 55 percent in the present case. These districts
probably have an irrigated area at the level of critical minimum
required for influencing the yield-growth. The yield growth during
1968-71 to 1974-77 was higher in adjoining districts than in semi-arid
districts and their extent of irrigation was also substantially higher.
This again indicates that the districts with a higher extent of
irrigation have obtained higher growth in per acre yield.

     There was a substantial increase in the number of electric and oil
engine pumps in both sets of districts (Table 5). The availability of
pump sets per 1000 hectares of cropped area in both the years, i.e. 1966
and 1972, was quite low in semi-arid districts as compared with adjoining
districts. This clearly supports the hypothesis about underinvestment
in agriculture in semi-arid areas, particularly in irrigational items
like pump sets -- probably because of the groundwater in these areas.

However, the increase in pump sets did not influence the yield growth in most districts. Irrigation through pump sets were expected to have a positive relationship with the yield-growth, because this provides a substantive type of irrigation with an assured supply of water at the required time. But surprisingly, even this source of irrigation was not found helpful to the yield-growth. It seems that in recent years there has been short supply of electricity to pump sets, which affected the intensity of irrigation and hence yield per hectare.

On a cross section basis, it appears that the availability of pump sets has influenced yield-growth. This could be seen from the fact that in the adjoining districts, the availability of pump sets has been much higher than in the semi-arid districts and these districts have also obtained higher yield-growth in the later period i.e. 1968-71 to 1974-77 than the semi-arid districts. It may be mentioned here that the relationship does not seem to hold on a temporal basis, probably due to the constraint of electricity supply to pump sets mentioned above.

Tractor Use

It has been observed that the regions which have appropriated the bulk of gains of new technology, have started using tractors, resulting reduced employment per unit of output. But since the new technology has also helped the more intensive use of land, it has resulted in greater employment as well as an increase in the earnings of agricultural workers. But in the drought-prone districts of UP a declining trend has been observed in crop intensity. Therefore, it is surmised that tractor use in these districts might lead to a decrease in employment and total earnings of agricultural workers. Despite the low density of population in drought-prone districts, there are no opportunities for employment except agriculture. In such a situation, agricultural development alone provides the main source of income and employment for people, at least in the short run. But the scope for increasing output, employment and incomes from agriculture is also limited in these areas, particularly in the absence of crop technology suited to their conditions.

The availability of tractors per 1000 hectares of cropped area (Table 6) indicates that in this respect the semi-arid districts are by and large at par with adjoining districts. This supports the hypothesis mentioned earlier that in semi-arid areas, farmers are forced to use tractors due to the short time available for sowing operations. However, in most of the semi-arid districts, growth rates of crop output and yield declined in the later period i.e. 1968-71 to 1974-77, despite the increase in availability of tractors in 1972 over 1966, and despite the higher number of tractors as compared to non-arid districts in 1972,

indicating thereby that the availability of tractors has not been helpful
in influencing the yield-growth in semi-arid districts. The greater use
of tractors is probably due more to short duration of sowing than to
trying for greater yield. However, in adjoining districts, the availability
to tractors seems to have had some influence on yield-growth.

The other aspect of tractor use is crop intensity, which has recently
shown a decreasing tendency in the semi-arid districts. Only in Jalaun and
Mirzapur has there been an increase in crop intensity, but in the former
the increase was a marginal 1.96 percent. In most adjoining districts
also, there was a marginal increase in crop intensity. Therefore, it could
be said that unlike in the adjoining districts, the tractor use in semi-
arid districts might reduce the total labor use per hectare, and thus affect
the total earnings of agricultural labor.

Density of Rural Population

The density of rural population is quite high in adjoining districts. In
some cases, it is two to three times the density in the semi-arid districts.
By and large, the yield-growth also appears to be higher in adjoining
districts than in the semi-arid districts (Table 6). The higher yield-
growth in the more densely-populated districts may be explained by the fact
that population pressure forces the cultivators to adopt new technology for
meeting the requirements of the increasing population.[10]

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10 Ester Boserup, "The Conditions of Agricultural Growth: The Economic
    Agrarian Change Under Population Pressure", George Allen & Unwin,
    London, 1965.

The direction of causation underlying the above phenomenon may be inter-
preted in two ways. As population increases, there may not be enough
scope for extending the margin of cultivation and increase in yield is
expected through capital investment and from the utilization of already
higher availability of agricultural labor. In this case, population
increase is considered an independent variable for the growth of crop
output. Alternatively, the areas of higher yield-growth may favor
increase in population. This explanation falls under the Malthusian
framework in which population density has been used to explain through
yield-growth. In this case, an increase in population is expected to
reduce the marginal value productivity of labor to a very low level and
in some cases to zero. However, marginal value of productivity of
labor in the given situation happens to be not only positive but also,
in most cases, it is higher than the wage rates in most parts of the
country. Under such a situation, the Malthusian argument does not seem
to be applicable in the sense that agricultural production could be
increased by the use of labor so long as its marginal productivity is
positive. The population increase may, therefore, generate sufficient
output growth to support itself. It is based on this premise as well
as in view of the fact that under population pressure the farmers
often make more capital investment which raises yield, that we have
tried to explain the association between yield-growth and population
density.

SUMMARY AND CONCLUSIONS

The above discussion may be summarized as follows:

1.   The disparities in crop output-growth between the semi-arid and
adjoining districts showed a narrowing tendency in the earlier period,
i.e. 1962-65 to 1968-71, which may be due to the initial low level of
crop output of semi-arid districts. After the initial phase, when
the crop output witnessed a deceleration in its growth, the disparities
in deceleration of crop output between the semi-arid and adjoining
districts increased.

2.   Area contributed marginally to output growth mainly in the earlier
period (1962-64 to 1968-71). The contribution of yield increase to
output growth was high in most of the districts in the earlier period,
whereas in the second period (1968-71 to 1974-77), the yield declined
in most of the semi-arid districts. However, in some of the adjoining
districts, the yield increase accounted for a substantial portion of
output growth. As regards crop pattern, its contribution was positive
in both periods in some semi-arid districts. This suggests that whenever
shifts in crop pattern from low- to high-value crop have occurred in
the semi-arid districts in the initial period, they have tried to maintain
a similar shift in the later period also.

3.   As regards factors explaining the yield-growth, it has been observed
that districts with larger holdings have lower yield-growth. In semi-arid
districts, the increase in fertilizer use, irrigated area, pumpsets and
tractor use were not helpful in influencing the yield-growth. But in
adjoining districts, it appears that these factors were to a certain
extent responsible for yield-growth. Population pressure has also exerted
its influence on yield-growth in those districts.

     The major difference in the pattern of crop output growth between
the semi-arid and adjoining areas observed in the above analysis consists
in the former not being able to maintain the output levels reached in the
earlier phase of the period covered here in subsequent years, as compared
to the increasing output levels, even though at a declining rate, in the
adjoining districts. As mentioned earlier, this difference is more or
less fully explained by the pattern of yield-growth in the two groups of
districts in the two phases. The question that arises is why the semi-
arid districts could not maintain their yield levels despite increasing
application of yield-enhancing factors. One explanation is that the
semi-arid districts experienced a growth in the earlier period mainly in

the case of wheat crop which was grown in whatever irrigated area was
available using new technology consisting of high-yielding seeds and
fertilizers; but the scope for increasing yield of wheat on those very
farms was more or less exhausted in a few years, and lack of irrigation
restricted the scope of extending the area under wheat crop with new
technology. At this stage, wheat to some extent became an uncertain crop,
and the farmers in semi-arid districts tended to restrict growth of the
area under wheat and shifted to more certain crops like masur (an
indigenous pulse variety), linseed, and rapeseed which required smaller
doses of water. Although gram and masur fetched similar prices per
quintal and neither of them required substantial irrigation, the area
under masur increased while that under gram declined probably because
yield per hectare started showing a declining trend in gram and therefore
did not remain as paying as masur. It appears that with the scope for
taking advantage of new technology for increasing the yield and output of
wheat being limited, the farmers preferred to choose between the crops
grown under low-yielding traditional technology, on the basis of per
acre physical yield and price parity, instead of applying increasingly
large doses of modern inputs without a certainty of high yield in wheat.
One possibility, therefore, to have a sustained level of output and its
growth in the semi-arid districts is to develop high-yielding varieties
in dry crops like gram and masur which do not require substantial
irrigation.

A sure and long term solution, however, seems to be public invest-
ment on a large scale in irrigation. Provision of irrigation would
bring results mainly by changing crop pattern and crop intensity, while
improvement in technology in dry crops will enhance output of these
districts through an increase in yield per hectare of these crops.
Our analysis suggests that marginal increases in irrigation and other
inputs do not seem to have a positive effect on yield and output growth
probably because there is a critical minimum level of these inputs and
only beyond this level does any marginal improvement in their application
yield a positive response. This may call for a massive program of
irrigation, particularly of the minor category like pumpsets and oil
engine irrigation which have shown some positive results in these
districts.

In the absence of assured irrigation on a large scale, it is but
natural that the farmers like to avert the risk of crop failure by
applying larger doses of yield-enhancing inputs on crops which depend
on water. Their strategy, therefore, to adopt the traditional technology
in such crops to minimize risk or to shift to rainfed, even though low-
yielding crops, is but a choice among such crops on the basis of expected
yields and prices. It thus looks essential to develop a new crop
technology for rainfed crops in order to make them high yielding, as an
alternative to developing large-scale irrigation which may prove highly
costly in these districts and can be attained only in the long run.

Table 1. Crop output growth in semi-arid districts and adjoining districts of Uttar Pradesh for two periods: 1962-65 to 1968-71 and 1968-71 to 1974-77.

| District | 1962-65 to 1968-71 | | 1968-71 to 1974-77 | | Change in growth |
	Index of local production in 1968-71 (1962-65 = 100)	Annual rate of increase (%)	Index of local production in 1974-77 (1968-71 = 100)	Annual rate of increase (%)	rates (%) in the period 1968-71 to 1974-77 over 1962-65 to 1968-71
I. Semi-Arid					
1. Jhansi	127	2.73	95	-0.56	-3.29
2. Jalaun	107	0.71	111	1.14	0.43
3. Hamirpur	140	3.85	81	-2.26	-6.11
4. Handa	120	2.09	82	-2.14	-4.22
5. Mirzapur	108	0.87	81	-2.30	-0.38
II. Adjoining districts					
1. Etawah	133	3.25	116	1.64	-1.61
2. Kanpur	118	1.87	117	1.73	-0.15
3. Fatehpur	106	0.69	107	0.80	0.11
4. Allahabad	104	0.40	124	2.45	2.05
5. Varanasi	114	1.48	109	0.92	-0.55

Table 2(a). Relative contributions of different components to output growth in semi-arid districts and adjoining districts of Uttar Pradesh for two periods: 1962-65 to 1968-71 and 1968-71 to 1974-77.

1962-65 to 1968-71
Percent increase attributed to

District	Area	Yield	Crop Pattern	Area and yield	Area and crop pattern	Yield & crop pattern	Area, yield & crop pattern	Total
I. Semi-Arid								
1. Jhansi	23.1 (0.6)	56.1 (1.5)	12.3 (0.3)	3.6 (0.1)	0.8 (0.0)	3.9 (0.1)	0.2 (0.0)	100.0 (2.7)
2. Jalaun	108.6 (0.8)	-27.7 (-0.2)	33.4 (0.2)	-2.0 (0.0)	2.4 (0.0)	-13.7 (-0.1)	-1.0 (0.0)	100.0 (0.7)
3. Hamirpur	9.4 (0.4)	78.6 (3.0)	1.9 (0.1)	3.0 (0.1)	0.1 (0.0)	6.7 (0.3)	0.3 (0.0)	100.0 (3.9)
4. Banda	13.5 (0.3)	80.8 (1.7)	-0.9 (0.0)	2.2 (0.0)	0.0 (0.0)	4.3 (0.1)	0.1 (0.0)	100.0 (2.1)
5. Mirzapur	-42.6 (-0.5)	147.7 (1.8)	10.5 (0.1)	-7.4 (-0.1)	-5.5 (0.0)	-8.0 (-0.1)	0.4 (0.0)	100.0 (1.2)
II. Adjoining Districts								
1. Etawah	20.2 (0.7)	58.7 (1.9)	5.6 (0.2)	4.0 (0.1)	0.4 (0.0)	10.5 (0.3)	0.7 (0.0)	100.0 (3.3)
2. Kanpur	5.2 (0.1)	86.1 (1.6)	2.3 (0.0)	0.8 (0.0)	0.0 (0.0)	5.5 (0.1)	0.1 (0.0)	100.0 (1.9)
3. Fatehpur	30.4 (0.2)	37.4 (0.3)	55.2 (0.4)	0.7 (0.0)	1.1 (0.0)	-24.3 (-0.2)	-0.5 (0.0)	100.0 (0.7)
4. Allahabad	1.6 (0.0)	41.7 (0.2)	56.7 (0.2)	0.0 (0.0)	0.0 (0.0)	-0.1 (-0.0)	0.0 (-0.0)	100.0 (0.4)
5. Varnasi	24.1 (0.4)	63.8 (0.9)	-5.2 (0.1)	2.2 (0.0)	-0.2 (0.0)	14.8 (0.2)	0.5 (0.0)	100.0 (1.5)

Table 2(b). Relative contributions of different components to output growth in semi-arid districts and adjoining districts of Uttar Pradesh for two periods: 1962-65 to 1968-71 and 1968-71 to 1974-77.

District	1968-71 to 1974-77 Percent increase attributed to							
	Area	Yield	Crop pattern	Area & yield	Area & crop pattern	Yield & crop pattern	Area, yield & crop pattern	Total
I. Semi-Arid								
1. Jhansi	-211.3 (1.2)	165.3 (-0.9)	-12.7 (0.4)	17.2 (-0.1)	-1.3 (0.0)	129.5 (-0.7)	13.4 (-0.6)	100.0 (-0.6)
2. Jalaun	-37.5 (-0.4)	115.2 (1.3)	34.2 (0.4)	-4.7 (0.0)	-1.4 (0.0)	-6.1 (-0.1)	0.2 (0.0)	100.0 (1.1)
3. Hamirpur	17.1 (-0.4)	84.4 (-1.9)	2.5 (-0.1)	-2.7 (0.1)	-0.1 (0.0)	-1.3 (0.0)	0.0 (0.0)	100.0 (-2.3)
4. Banda	9.4 (-0.2)	95.5 (-2.0)	-2.7 (0.1)	-1.6 (0.0)	0.0 (0.0)	-0.6 (0.0)	0.0 (0.0)	100.0 (-2.1)
5. Mirzapur	135.7 (1.2)	-48.0 (-0.4)	29.7 (0.3)	-5.3 (0.0)	3.3 (0.0)	-13.8 (-0.1)	-1.5 (0.0)	100.0 (0.7)
II. Adjoining Districts								
1. Etawah	-26.1 (-0.4)	110.5 (1.8)	25.1 (0.4)	-4.5 (-0.1)	-1.0 (0.0)	-4.1 (-0.1)	0.2 (0.0)	100.0 (1.6)
2. Kanpur	-10.3 (-0.2)	88.0 (1.5)	13.6 (0.2)	-1.5 (0.0)	-0.2 (0.0)	10.7 (0.2)	-0.2 (0.0)	100.0 (1.7)
3. Fatehpur	-0.5 (0.0)	73.5 (0.6)	19.3 (0.2)	0.0 (0.0)	0.0 (0.0)	7.8 (0.1)	0.0 (0.0)	100.0 (0.8)
4. Allahabad	-8.0 (-0.2)	94.3 (2.3)	4.1 (0.1)	-1.8 (0.0)	-0.1 (0.0)	11.7 (0.3)	-0.2 (0.0)	100.0 (2.4)
5. Varanasi	-15.6 (-0.1)	61.5 (0.6)	60.5 (0.6)	-0.8 (0.0)	-0.8 (0.0)	-4.9 (0.0)	0.1 (0.0)	100.0 (0.9)

Table 3. Yield growth, size of holding, land concentration ratio, pattern of ownership and soil rating in semi-arid districts and adjoining districts of Uttar Pradesh.

| District | Yield Growth Rates(%) | | As per Agricultural Census 1971 | | | |
	1962-65 to 1968-71	1968-71 to 1974-77	Average size of holding (ha)	Land con-centration ratio	Percentage of owned area to total area	Soil rating
I. Semi-Arid						
1. Jhansi	1.53	-0.92	2.60	0.55	0.90	61
2. Jalaun	-0.20	1.32	2.70	0.55	0.97	61
3. Hamirpur	3.03	-1.91	2.96	0.56	0.94	61
4. Banda	1.68	-2.04	2.37	0.59	0.95	54
5. Mirzapur	1.84	-0.42	1.84	0.60	0.87	58
II. Adjoining Districts						
1. Etawah	1.91	1.81	1.15	0.53	0.98	68
2. Kanpur	1.61	1.52	1.14	0.57	0.98	69
3. Fatehpur	0.26	0.59	1.41	0.57	0.97	65
4. Allahabad	0.17	2.31	1.14	0.61	0.98	61
5. Varanasi	0.94	0.56	0.74	0.58	0.97	61

Table 4.   Yield-Growth and fertilizer use in semi-arid districts and adjoining districts of Uttar Pradesh

District	Yield-Growth(%)		Per hectare fertilizer use in kilograms									
			P2 O5					N2				
	1962-65 to 1968-71	1968-71 to 1974-77	1962-63	1969-70	1975-76	% change in		1962-63	1969-70	1975-76	% change in	
						1969-70 over 1962-63	1975-76 over 1969-70				1975-76 over 1962-63	1975-76 over 1969-70
I. Semi-Arid												
1. Jhansi	1.53	-0.92	0.09	0.99	1.19	1000	20	0.40	2.20	3.42	450	54
2. Jalaun	-0.20	1.32	0.20	2.97	1.90	1385	-36	0.82	4.45	7.32	443	64
3. Hamirpur	3.03	-1.90	0.18	0.49	0.44	172	-10	0.12	0.99	1.34	725	35
4. Banda	1.68	-2.04	0.06	0.49	0.61	717	24	0.27	1.23	1.51	356	24
5. Mirzapur	1.84	-0.42	0.25	1.48	2.08	492	41	2.27	5.44	10.42	190	92
II. Adjoining Districts												
1. Etawah	1.91	1.81	0.23	2.47	1.78	974	-28	1.09	10.13	12.21	829	21
2. Kanpur	1.61	1.52	0.12	2.47	1.36	1958	-45	1.12	12.60	12.82	1025	2
3. Fatehpur	0.26	0.59	0.15	1.23	1.13	720	-8	0.77	6.67	10.71	766	61
4. Allahabad	0.17	2.31	0.29	2.72	1.33	838	-51	0.23	13.59	17.35	5809	28
5. Varanasi	0.94	0.56	0.41	6.18	3.62	1407	-41	1.50	16.06	36.60	971	128

Table 5.   Yield-growth, irrigated area and availability of electric and oil engine pumpsets in semi-arid districts and adjoining districts of Uttar Pradesh.

Districts	Yield-growth (%)		Percentage of gross irrigated to gross cropped area:					Electric and oil engine pumpsets per 1000 hectares		
	1962-65 to 1968-71	1968-71 to 1974-77	1962-63	1969-70	1975-76	1969-70 over 1962-63	1975-76 over 1969-70	1966	1972	Increase (times)
I. Semi-Arid										
1. Jhansi	1.53	-0.92	16.11	19.57	23.97	21.48	22.48	0.58	3.22	5.55
2. Jalaun	-0.20	1.32	27.18	34.18	29.09	25.75	-15.11	0.26	4.28	16.46
3. Hamirpur	3.03	-1.91	11.22	14.01	15.91	24.87	13.56	0.63	2.20	3.49
4. Banda	1.68	-2.04	16.63	14.53	19.53	-12.17	34.41	0.82	4.10	5.00
5. Mirzapur	1.84	-0.42	18.51	19.72	21.74	6.34	10.24	0.56	8.03	14.34
II. Adjoining Districts										
1. Etawah	1.91	1.81	35.57	43.17	54.63	21.37	25.92	1.19	19.10	16.05
2. Kanpur	1.61	1.52	27.43	31.03	45.02	13.12	45.09	1.48	19.25	13.01
3. Fatehpur	0.26	0.59	23.86	27.54	34.21	15.42	24.22	1.60	14.05	8.78
4. Allahabad	0.17	2.31	18.44	22.63	36.65	22.72	61.95	1.60	10.91	6.82
5. Varanasi	0.94	0.56	35.73	40.34	47.26	12.90	17.15	0.84	16.47	19.61

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Table 6. Output and yield-growth, intensity of cropping, availability of tractors and population attributes in semi-arid districts and adjoining districts of Uttar Pradesh

Districts	Output growth 1968-71 to 1974-77 (%)	Yield-growth 1968-71 to 1974-77 (%)	Intensity of cropping (%)			Availability of tractors per 100 hectares			Population Attributes - 1971		
			1969-70	1975-76	Change in 1975-76 over 1969-70(%)	1966	1972	Increase (times)	Population increase in 1971 over 1961 (%)	% of rural population in total 100	Population density (rural persons per sq. kilometre)
I. Semi-Arid											
1. Jhansi	-0.56	-0.92	109	106	-2.90	0.40	0.57	1.45	20.2	75	99
2. Jalaun	1.14	1.32	104	106	1.96	1.26	3.06	2.42	22.7	86	155
3. Hamirpur	-2.26	-1.91	104	103	-0.53	0.36	0.49	1.35	24.4	90	124
4. Banda	-2.14	-2.04	116	116	-0.26	0.17	0.10	-0.60	24.0	92	142
5. Mirzapur	0.87	-0.42	119	129	8.61	0.61	0.79	1.30	23.6	88	121
II. Adjoining Districts											
1. Etawah	1.64	1.81	133	130	-2.33	0.14	0.74	5.43	22.5	90	303
2. Kanpur	1.73	1.52	120	121	0.10	0.24	0.29	1.22	25.8	57	285
3. Fatehpur	0.80	0.59	119	123	3.87	0.08	0.19	2.53	19.9	94	294
4. Allahabad	2.45	2.31	119	125	4.76	0.17	0.49	2.89	20.5	82	334
5. Varanasi	0.92	0.56	133	137	3.04	0.96	0.93	-0.96	20.6	75	430

APPENDIX I

Methodology

The output-growth for the purposes of decomposition analysis has been computed as the change in output in the current period (taken as an average of the last three years) over the base period (taken as an average of the first three years). The changes in components have also been similarly computed on the basis of three-year averages of the base and current years. Constant price weights have been assigned to different crops based on State prices.

Two alternative approaches are generally followed to explain output-growth: decomposition[1] and production function.[2] Since the objective here is to study the contribution of different components to the aggregate increase in crop output, use has been made of decomposition scheme, which could be additive or multiplicate. The additive decomposition scheme has been preferred to the multiplicate for the obvious reason that its results could be interpreted in a straightforward manner.[3] The increase in crop output over the period has been decomposed in different components in the following manner:

$$P_t - P_o = (A_t - A_o) \Sigma W_i C_{io} Y_{io} + A_o \Sigma W_i X_{io} (Y_{it} - Y_{io})$$

$$+ A_o \Sigma W_i (C_{it} - C_{io}) Y_{io}$$

$$+ (A_t - A_o) \Sigma W_i (Y_{it} - Y_{io}) C_{io}$$

$$+ (A_t - A_o) \Sigma W_i (C_{it} - C_{io}) Y_{io}$$

$$+ A_o \Sigma W_i (C_{it} - C_{io}) (Y_{it} - Y_{io})$$

$$+ (A_t - A_o) \Sigma W_i (Y_{it} - Y_{io}) (C_{it} - C_{io})$$

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1 For an application of this method, see Minhas, B.S. and Vidyanathan A. Growth of Crop Output in India 1951 to 1958-61 : An analysis by component element. _Journal of the Indian Society of Agricultural Statistics_, Vol. XVII, No.2, 1965, pp. 230-252.

2 The earliest attempt made on these lines in India, is by Raj Krishna, see his 'Growth of aggregate output in the Punjab,' _Indian Economic Journal_, Vol. XII, No. 1, July-Sept. 1964, pp. 53-59.

   We also sometimes find the simultaneous use of both methods. See for example, Parikh, Ashok, Statewise growth-rate in agricultural output - An Econometric Analysis, _Artha Vijnana_, Vol.8, No.1, March, 1966, pp. 1-52.

3 Cf. Mihas, B.S., Rapporteur's Report on Measurement of Agricultural Growth, _Indian Journal of Agricultural Economics_, Vol.XXI, No.4, Oct-Dec 1966, pp. 165-182.

where:

$P_t = A_t \Sigma W_i C_{it} Y_{it}$ = Index of crop output in the current year

$P_o = A_o \Sigma W_i C_{io} Y_{io}$ = Index of the crop output in the base year

A_t =   Cropped area in the current year

A_o =   Cropped area in the base year

C_{it} =   Proportion of area under the 'i' th crop to total gross cropped
              area in the current year

C_{io} =   Proportion of area under the 'i' the crop to total gross cropped area
              in the base year

Y_{it} =   Per acre yield of the 'i' th crop in the current year

Y_{io} =   Per acre yield of the 'i' th crop in the base year

W_i =   Constant price weight for the 'i' th crop of the selected years.

        The first term on the right hand side of the equation represents the
effect on crop output of changes in gross cropped area, in the absence of
yield and crop pattern changes. The second term is the effect of yield
changes, keeping the area and crop pattern of the base year. The third
element measures the effect of changes in crop pattern in the absence of
changes in yield per unit of land, with the fixed cropped area of the base
year. The last four elements bring out the effect of the interaction of
the three major components. These interactions are between: area and yield
with base year crop-pattern, area and crop-pattern with base year yield
level and crop-pattern and yield with fixed cropped area of base year. The
last element is a three-factor interaction between changes in area, yield and
crop-pattern.

        One of the main limitations of this scheme is that only a few years'
information for the base and current years has been generally used. The
implication for analysis is that such limited data need not necessarily
reflect the actual trends for all the years in the series, in which case
the estimate of the scheme would not be in conformity with the trends combining
all the years.

Appendix II: Percentage distribution of crops in semi-arid districts and adjoining districts of Uttar Pradesh: 1962-65 to 1974-77.

Districts	Masur	Gram	Tur	Til	Groundnut	Rapeseed	Linseed	Sunhemp	Sugarcane	Potato	Total gross cropped area in '000 ha.
I. Semi-arid											
1. Jhansi											
1962-65	1	24	4	4	0	0	1	0	0	0	479
1968-71	2	24	3	3	0	0	0	0	0	0	509
1974-77	2	20	4	1	0	0	2	0	0	0	562
2. Jalaun											
1962-65	1	39	6	0	0	2	2	0	1	0	351
1968-71	3	37	5	0	1	1	1	0	0	0	376
1974-77	9	28	4	0	0	2	4	0	0	0	361
3. Hamirpur											
1962-65	1	35	7	5	0	0	2	1	0	0	501
1968-71	1	38	6	4	1	0	1	0	0	0	520
1974-77	2	36	6	4	0	1	2	1	0	0	503
4. Banda											
1962-65	2	34	6	1	1	0	1	0	0	0	558
1968-71	2	35	5	1	1	0	1	0	0	0	573
1974-77	4	30	6	1	0	0	1	0	0	0	564
5. Mirzapur											
1962-65	1	11	5	1	0	1	5	0	1	0	439
1968-71	1	9	5	2	0	1	3	0	1	0	417
1974-77	1	9	5	1	0	1	4	0	1	0	463
II. Adjoining Districts											
1. Etawah											
1962-65	0	14	6	0	0	4	1	0	2	1	348
1968-71	0	10	5	0	0	4	1	0	2	1	371
1974-77	0	8	4	0	0	8	1	0	1	2	355
2. Kanpur											
1962-65	0	17	6	0	1	4	0	0	2	1	501
1968-71	0	16	5	0	1	5	1	0	1	1	506
1974-77	0	13	5	0	1	8	0	0	1	1	498
3. Fatehpur											
1962-65	0	23	6	0	0	1	0	1	2	1	335
1968-71	0	21	5	0	0	1	0	1	2	1	341
1974-77	0	19	5	0	0	1	0	0	2	1	341
4. Allahabad											
1962-65	1	17	5	0	1	0	2	1	1	1	577
1968-71	1	14	5	0	1	0	2	1	1	1	577
1974-77	1	12	5	0	0	0	2	0	1	1	566
5. Varanasi											
1962-65	0	9	5	0	1	0	1	4	5	1	407
1968-71	0	7	5	0	0	0	1	3	4	1	421
1974-77	0	6	5	0	0	0	1	3	5	1	415

Appendix II: Percentage distribution of crops in semi-arid districts and adjoining districts of Uttar Pradesh: 1962-65 to 1974-77.

District	Rice	Jowar	Bajra	Maize	Madua	Sawan	Koda	Kadun	Kutki	Barley	Wheat	Urd	Peas
I. Semi-Arid													
1. Jhansi													
1962-65	5	23	0	2	-	0	3	0	1	2	27	2	0
1968-71	3	22	0	3	-	0	2	0	1	2	31	2	0
1974-77	3	19	0	12	-	0	2	0	0	1	29	2	0
2. Jalaun													
1962-65	2	13	3	0	-	0	0	0	-	3	26	0	2
1968-71	3	8	6	0	-	0	-	-	-	3	30	0	2
1974-77	2	7	5	1	-	0	-	-	-	3	33	0	1
3. Hamirpur													
1962-65	1	20	2	0	-	0	1	0	-	1	24	1	0
1968-71	1	16	1	1	-	0	1	0	-	1	27	1	0
1974-77	1	19	0	1	-	0	1	0	-	1	25	1	0
4. Banda													
1962-65	17	14	3	0	-	0	1	0	-	2	20	0	0
1968-71	14	13	4	0	-	1	1	0	-	3	20	0	0
1974-77	16	14	3	1	-	0	1	0	-	3	21	0	0
5. Mirzapur													
1962-65	32	2	2	3	0	5	5	0	-	12	11	1	1
1968-71	31	2	3	4	0	6	6	0	-	10	13	1	1
1974-77	30	2	3	4	0	6	5	0	-	10	16	1	1
II. Adjoining Districts													
1. Etawah													
1962-65	16	4	16	7	0	0	-	0	-	6	16	0	9
1968-71	15	3	16	9	-	0	-	0	-	5	25	0	5
1974-77	16	2	15	7	-	0	-	1	-	5	27	0	4
2. Kanpur													
1962-65	13	12	6	5	0	0	-	0	-	9	17	0	5
1968-71	13	10	7	6	-	0	-	0	-	9	22	1	3
1974-77	13	9	6	6	-	0	0	0	-	7	26	1	2
3. Fatehpur													
1962-65	20	14	4	0	0	0	-	0	-	14	11	1	2
1968-71	19	11	6	0	0	0	-	0	-	14	14	1	1
1974-77	20	10	4	0	0	0	0	0	-	11	20	1	1
4. Allahabad													
1962-65	25	7	9	0	0	0	1	0	-	13	11	0	5
1968-71	23	6	11	0	1	1	1	0	-	14	14	0	4
1974-77	25	6	11	0	0	0	1	0	-	10	23	0	3
5. Varanasi													
1962-65	37	1	3	2	0	2	0	0	-	13	10	1	6
1968-71	34	1	4	4	0	2	0	0	-	13	13	1	5
1974-77	34	-	4	4	0	2	0	-	-	10	21	1	4